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NRE Staff Report

1979 FALL POTATO PESTICIDE USE IN THE NORTH CENTRAL REGION

by

John R. Parks

August 1982

ERS Staff Report No. AGES820805

Natural Resource Economics Division
Economic Research Service
U.S. Department of Agriculture
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ABSTRACT

A survey of pesticide use in fall potato production was conducted by the U.S. Department of Agriculture in 1979. Information is reported for Michigan, Minnesota, North Dakota, and Wisconsin. An estimated 2.9 million pounds (active ingredient) of pesticides were used. Growers treated more land with insecticides than with any other pesticide category, 96 percent of the potato acreage. About 2.2 million acre-treatments were made with pesticides using 1.3 pounds (a.i.) per acre-treatment. Fungicides were used in 1.0 million, or 47 percent of all acre-treatments. Herbicides, vine killers, and growth regulators were less important. Coefficients of variation were calculated for acres treated with specific pesticides.

Key words: Pesticides, potatoes (fall), herbicides, fungicides, insecticides, vine killers, growth regulators.

ACKNOWLEDGMENTS

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INTRODUCTION

This report presents the kinds and amounts of pesticides used on fall potatoes harvested in the North Central region (Michigan, Minnesota, North Dakota, and Wisconsin) (Figure 1). Information is reported on treated acres, acre-treatments, quantities of pesticides applied, application rates, and times applied.

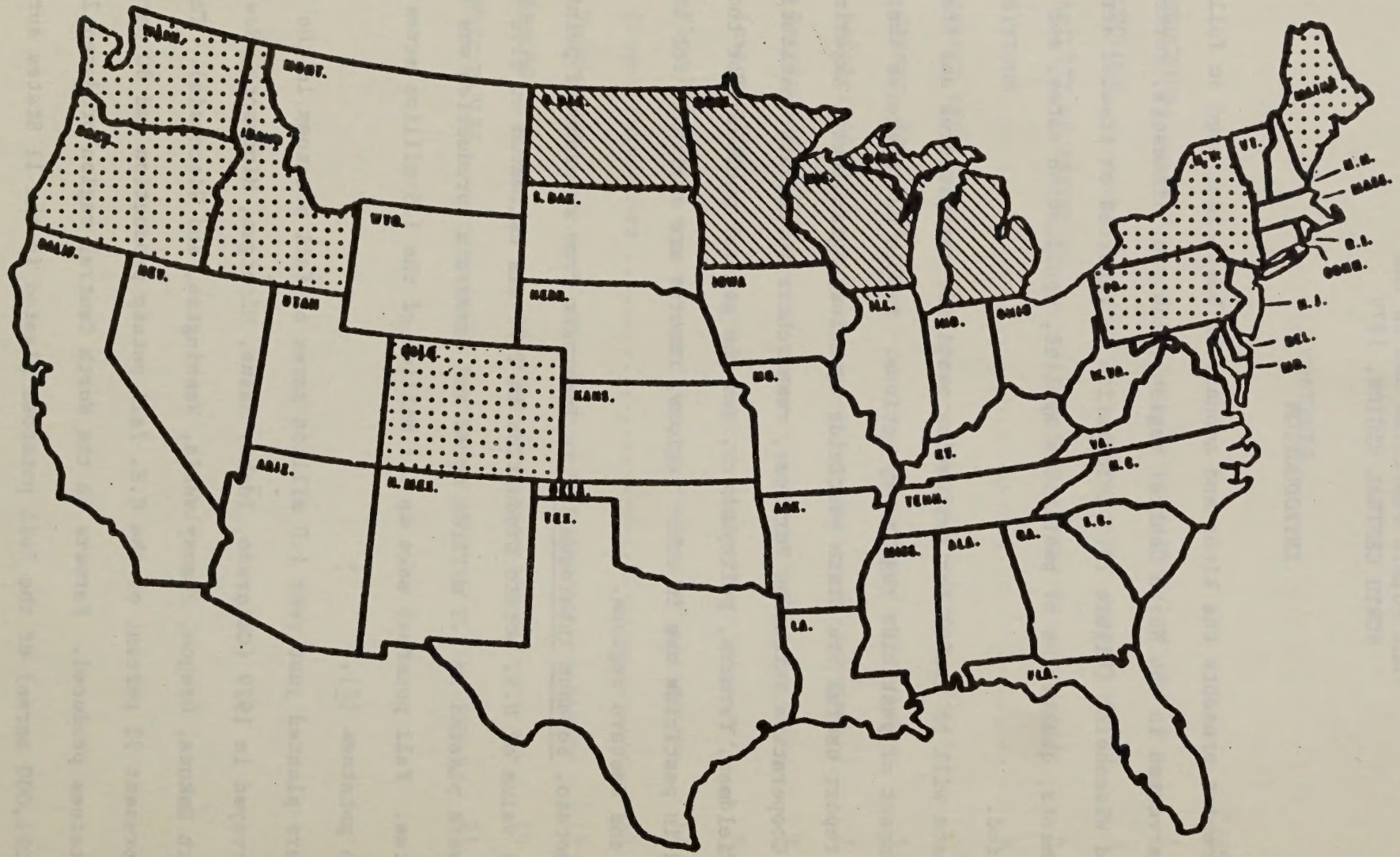
The data will be useful for evaluating pesticide use patterns and the economic impact of pesticide regulatory actions. People and agencies that will find this report useful are State pesticide agencies, Agricultural Experiment Stations, Cooperative Extension Services, researchers in private institutions, industry fieldmen, farmers, policymakers, and the general public. For those interested in pesticide use in other regions, reports are available for the Northeast and Western regions.

The potato, Solanum tuberosum L., is important from an economic point of view. The value of U.S. potato production in 1979 was estimated at $1.2 billion. Potatoes were planted on 1.3 million acres and commercial production was reported in 39 States. Fall potatoes make up 1.1 million of the 1.3 million acres planted to potatoes (7).

Growers planted just over 1.0 million acres of fall potatoes in the 11 States surveyed in 1979 (Colorado, Idaho, Maine, Michigan, Minnesota, New York, North Dakota, Oregon, Pennsylvania, Washington, and Wisconsin). These States represent 92 percent of the U.S. fall potato production and 80 percent of all potatoes produced. Farmers in the North Central region produced 28 percent (281,000 acres) of the fall potatoes planted in the 11 States surveyed.

Pesticides are important in potato production. Pesticides control weeds,

Figure 1. States included in the 1979 Fall Potato Pesticide Survey.



diseases, and insects that reduce yield and lower quality. From a cost standpoint pesticides are an important consideration. Research in North Dakota indicates that pesticide costs are about 18 percent of variable production costs (1).

METHODOLOGY

Data in this report were collected in conjunction with the 1979 Potato Objective Yield Survey conducted by the Economics, Statistics, and Cooperatives Service of the U.S. Department of Agriculture. Enumerators from the State Statistical Offices (SSO's) collected the pesticide data through personal interviews.

The sample design was a two-stage multiple frame sample. Sample fields were selected from a list of known growers (list frame) maintained by the SSO's. In addition, area tracts (area frame) were selected to insure that all growers had an opportunity to be included in the sample. Sample fields were randomly selected, and the probability of being selected was proportional to field size. The expansion factor for the State was derived by dividing the planted acres by the number of completed questionnaires. Out of 760 sample questionnaires, 528 were completed.

State	No. of samples	Questionnaires completed
Michigan	140	108
Minnesota	175	114
North Dakta	275	170
Wisconsin	170	136
Total	760	528

RELIABILITY OF ESTIMATES

Estimates based on surveys have varying degrees of statistical reliability. Confidence in data depends on sample size, sampling methods, and the variability of responses. To provide some indication of the reliability of the estimates, coefficients of variation (CV's) are presented in Appendix Tables 1 and 2. The CV is a measure of the relative variation (expressed in percentage terms) and can be used to indicate the degree of confidence a user can place in the estimate. The smaller the CV, the more reliable the estimate.

In simplest terms, it can be said there is a 95 percent confidence that the sample represents the true population and the true value for the population lies within an interval defined as $\pm$ 2 CV's times the estimated value. For example, with a CV of 10 percent and an estimate of 40, the interval would be 32 to 48. However, there is also a 5 percent chance that the true value does not fall within the interval as defined above because the sample may not be representative of the population.

CV's were calculated only for acres treated with specific pesticides. Estimates of acres treated are expected to have greater variation than other data reported. Consequently, for most other information included in this report, the level of reliability should be equal to or greater than information reported for acres treated.

DEFINITIONS

For a clearer understanding of the data, a number of terms are defined as follows:

Active ingredient - Pesticide quantities are expressed in terms of active ingredients (a.i.). This is the chemical substance that controls the pest. Inert ingredients such as talc, clay, or solvents used as carriers are not

included in the quantity estimates.

Times applied is the number of times a land area was treated with a specific pesticide.

Treated acres is the land area treated with a specific pesticide one or more times. Acres treated with different pesticides cannot be summed because a given land area may have been treated with more than one pesticide.

Acre-treatment is the acres treated with a specific pesticide times the number of applications. The acre-treatment calculation includes the area and number of applications. Acre-treatments of different pesticides can be summed without double counting.

Tank-mix is two or more pesticides mixed in the spray tank and applied in a single application.

THE SURVEY RESULTS

General Pesticide Use

In terms of acres treated, insecticides were the most important pesticide category used on potatoes in the North Central region. Growers planted 281,000 acres of potatoes, of which 96 percent (270,000 acres) were treated with insecticides (Table 1). Fungicides were second in importance, 81 percent. About 228,000 acres of potatoes were treated with fungicides to control or prevent diseases. Herbicide use varied more by State than did the other categories of pesticides. Herbicides were used more extensively in Michigan and Wisconsin. Vine killers were not widely used because climatic conditions in the region cause the vines to dry naturally in the fall or they are killed by frost (2). Growth regulators, applied in the field, were used on about 28,000 acres or 10 percent of the land planted to potatoes (Table 1).

Growers in the North Central region indicated that they used almost 2.9 million pounds (a.i.) of pesticides on fall harvested potatoes (Table 2).

Table 1. Fall potato acreage and proportion treated with pesticides in the North Central region, 1979, a/

State	Acres planted	Proportion treated with: Herbicides	Fungicides	Insecticides	Vine killers	Growth regulators
	1,000	Percent				
Michigan	33	93	97	98	78	6
Minnesota	70	31	86	97	65	5
North Dakota	121	25	65	92	31	11
Wisconsin	57	94	99	100	74	17
Total	281	48	81	96	55	10

a/ "1979 Fall Potato Pesticide Survey", USDA, ESCS, Natural Resource Economics Division.

Table 2. Summary of pesticides used on fall potatoes in the North Central region, 1979 a/

Pesticides	Acre-treatment		Quantity applied (a.i.) Total	Share of total	Per acre treatment	Times applied
	1,000	Percent	1,000 lbs.	Percent	Lbs.	No.
Single applications						
Herbicides	149	7	253	9	1.7	1.0-1.1
Fungicides	1,032	47	1,139	40	1.1	2.4-5.5
Insecticides	607	28	670	23	1.1	1.0-2.6
Vine killer	187	9	336	12	1.8	1.2
Growth regulator	29	1	88	3	3.0	1.0
Tank-mixes	181	8	370	13	2.0	1.0-3.9
Total	2,185	100	2,856	100	1.3	-

a/ "1979 Fall Potato Pesticide Survey," USDA, ESCS, Natural Resource Economics Division.

Growth regulators used in storage, as well as pesticides for seed treatment, and chemicals applied to facilities and equipment were excluded. Growers made about 2.2 million acre-treatments of pesticides averaging 1.3 pounds (a.i.) per acre. The survey shows that fungicide treatments were 47 percent of all pesticide acre-treatments and 40 percent of the total quantity (a.i.) (Table 2).

Herbicides

Growers in the North Central region made almost 150,000 acre-treatments using about 250,000 pounds (a.i.) of herbicides (Table 3). Herbicides were applied on the average about one time per season. Metribuzin was used in more acre-treatments than any other herbicide, 39 percent of all acre-treatments. The survey did not measure any use of metribuzin in North Dakota (Table 3); although it is believed that some is used (4). Dry growing conditions may be a reason for not using metribuzin in North Dakota. Metribuzin requires moisture shortly after treatment to be effective. The climate and irrigation in Michigan and Wisconsin favor the use of metribuzin, and it was the most common herbicide reported there. Metribuzin is a pre- and postemergent herbicide that controls most common broadleaf weeds including velvetleaf, ragweed, and barnyardgrass which are common in the North Central region (5), (8).

EPTC was the second most commonly used herbicide on a regional basis. It was applied in 41,000 acre-treatments, 27 percent of all herbicides. EPTC was applied at an average of 3.4 pounds (a.i.) per acre-treatment, with a total quantity of 136,000 pounds (a.i.) applied in the North Central region. EPTC was the only herbicide reported in North Dakota; it was second in importance in Minnesota. In these two States, EPTC was broadcasted and incorporated into the soil before planting. EPTC is a selective preplant herbicide applied prior to weed germination. It controls lambsquarters, quackgrass, and pigweed among other weeds in North Dakota and Minnesota (5).

Table 3. Herbicide use on fall potatoes in the North Central region, 1979 a/

State and herbicide	Treated acres b/	Acre-treatment	Quantity applied (a.i.) Total	Per acre Treated	Per acre Treatment	Times applied
	1,000		1,000 lbs.	Lbs.		No.
Michigan						
Alachlor	4.3	4.3	8.4	2.0	2.0	1.0
EPTC	3.4	3.4	12.4	3.6	3.6	1.0
Linuron	10.9	10.9	8.2	.8	.8	1.0
Metribuzin	14.8	17.6	7.8	.5	.4	1.2
Other	-	2.5	6.1	-	2.4	-
Total	-	38.7	42.9	-	1.1	-
Minnesota						
EPTC	6.7	6.7	27.3	4.1	4.1	1.0
Linuron	3.9	3.9	5.7	1.5	1.5	1.0
Metribuzin	9.1	11.1	6.6	.7	.6	1.2
Other	-	1.0	1.8	-	1.8	-
Total	-	22.7	41.4	-	1.8	-
North Dakota						
EPTC	26.6	26.6	83.4	3.1	3.1	1.0
Wisconsin						
Alachlor	7.1	7.9	16.5	2.3	2.1	1.1
Chlorobromuron	1.3	1.3	2.5	1.9	1.9	1.0
Dalapon	4.2	4.2	23.4	5.6	5.6	1.0
EPTC	3.0	3.8	13.3	4.4	3.5	1.3
Linuron	11.9	11.9	10.3	.9	.9	1.0
Metribuzin	28.4	30.1	17.6	.6	.6	1.1
Other	-	1.9	1.9	-	1.0	-
Total	-	61.1	85.5	-	1.4	-
4 States c/						
Alachlor	11.9	12.7	26.3	2.2	2.1	1.1
Chlorobromuron	1.6	1.6	3.1	1.9	1.9	1.0
Dalapon	4.3	4.3	24.0	5.6	5.6	1.0
EPTC	39.7	40.6	136.4	3.4	3.4	1.0
Linuron	26.7	26.7	24.2	.9	.9	1.0
Metribuzin	52.3	58.8	32.0	.6	.5	1.1
Other	-	4.5	7.2	-	1.6	-
Total	-	149.2	253.2	-	1.7	-

a/ "1979 Fall Potato Pesticide Survey," USDA, ESCS, Natural Resource Economics Division.

b/ Data in this column for "other" and "total" were not reported because two or more materials may have been used on the same acre, resulting in multiple counting.

c/ Regional totals for specific materials may differ from the total for individual States because in some instances materials were included in the "other" category for State reporting.

Linuron was the second most commonly used herbicide in Michigan and Wisconsin. It controls lambsquarters, crabgrass, and pigweed in these States (5),(8).

Fungicides

Fungicides rank first in acre-treatments and the first in pounds (a.i.) of all pesticides used on potatoes (Table 2). Approximately 1.0 million acre-treatments were made and 1.1 million pounds (a.i.) were applied (Table 4).

Maneb/mancozeb was the most extensively used fungicide, accounting for almost 60 percent of the fungicide acre-treatments (Table 4). Chlorothalonil was second in use at 14 percent or almost 150,000 acre-treatments. These rankings at the regional level varied at the State level. For example, Michigan growers used more copper, making it second in use there. Copper was important in Michigan because it has been in use a long time, has fewer restrictions on use, and controls late blight (3). In North Dakota and Minnesota fentin hydroxide was second in importance and also used to control blight.

Maneb/mancozeb is largely used to control or prevent early or late blight on potatoes. It is applied to the foliage and the extent of use is influenced by weather conditions that favor disease development (6). Maneb/mancozeb has been in use for a number of years, controls a wider range of diseases than any other fungicide, and is compatable with a number of insecticides and other fungicides (6). Chlorothalonil does not have the range of disease control as maneb/mancozeb but it controls early and late blight on potatoes, which accounts for its extensive use in the region.

Insecticides

Insects were the most pervasive pest problem in the North Central region. About 96 percent of all acres planted in potatoes were treated with an insecticide, 270,000 acres (Table 1). More different kinds of insecticides were used than

Table 4. Fungicide use on fall potatoes in the North Central region, 1979 a/

State and fungicide	Treated acres b/	Acre-treatment	Quantity applied (a.i.) Total	Per acre Treated	Per acre Treatment	Times applied
	1,000	1,000	1,000 lbs.	Lbs.	Lbs.	No.
Michigan						
Captafol	.9	1.8	2.4	2.7	1.3	2.0
Chlorothalonil	7.3	25.1	22.6	3.1	.9	3.4
Copper	16.0	41.5	42.7	2.7	1.0	2.6
Maneb/mancozeb c/	21.3	139.7	194.1	9.1	1.4	6.6
Metiram	2.7	8.8	17.4	6.4	2.0	3.3
Other	-	.6	.2	-	.3	-
Total	-	217.5	279.4	-	1.3	-
Minnesota						
Chlorothalonil	3.1	14.5	15.6	5.0	1.1	4.7
Fentin hydroxide	6.6	17.5	3.2	.5	.2	2.7
Maneb/mancozeb	28.5	120.4	149.4	5.2	1.2	4.2
Metiram	2.8	5.7	5.0	1.8	.9	2.0
Total	-	158.1	173.2	-	1.1	-
North Dakota						
Chlorothalonil	1.9	5.8	5.1	2.7	.9	3.1
Fentin hydroxide	32.2	61.1	9.9	.3	.2	1.9
Maneb/mancozeb	42.0	71.8	82.9	2.0	1.2	1.7
Other	-	.6	.5	-	.8	-
Total	-	139.3	98.4	-	.7	-
Wisconsin						
Captafol	5.4	25.3	34.3	6.4	1.4	4.7
Chlorothalonil	14.7	103.5	84.6	5.8	.8	7.0
Copper	5.4	10.9	5.8	1.1	.5	2.0
Fentin hydroxide	8.0	58.3	12.5	1.6	.2	7.3
Maneb/mancozeb	37.0	280.3	399.4	10.8	1.4	7.6
Metiram	4.6	39.0	51.8	11.3	1.3	8.5
Total	-	517.3	588.4	-	1.1	-
4 States d/						
Captafol	6.9	27.7	37.2	5.4	1.3	4.0
Chlorothalonil	27.1	148.9	127.9	4.7	.9	5.5
Copper	21.5	52.4	48.5	2.3	.9	2.4
Fentin hydroxide	47.1	137.5	25.8	.5	.2	2.9
Maneb/mancozeb	128.8	612.2	825.8	6.4	1.3	4.8
Metiram	10.2	53.5	74.2	7.3	1.4	5.2
Total	-	1,032.2	1,139.4	-	1.1	-

a/ "1979 Fall Potato Pesticide Survey," USDA, ESCS, Natural Resource Economics Division.

b/ Data in this column for "other" and "total" were not reported because two or more materials may have been used on the same acre, resulting in multiple counting.

c/ Maneb and mancozeb are similar products; they are shown as one data entry.

d/ Regional totals for specific materials may differ from the total for individual States because in some instances materials were included in the "other" category for State reporting.

any other pesticide (Table 5). Azinphosmethyl, carbaryl, methamidophos, and aldicarb were used most extensively of the many insecticides reported. The use of these four chemicals are within the range of about 50,000 to 100,000 acre-treatments each and they made up for 53 percent of all insecticides.

Azinphosmethyl is widely used in Minnesota and North Dakota for flea beetles, potato leaf hopper, and Colorado potato beetle control. The first ranking insecticide in Michigan was parathion and in Wisconsin, methamidophos. Parathion was used to control potato leaf hopper and methamidophos to control potato leaf hopper, potato flea beetle, potato aphid, and the green peach aphid.

Two insecticides, aldicarb and phorate, are registered for nematode control. Because of the limited number of observations the information for them is reported under insecticides.

Vine killers

Vine killers are used as a harvest aid to dry out the vines and set the skins; this facilitates digging and reduces bruising. In the North Central region over half or about 155,000 acres of potatoes were treated with a vine killer (Table 1). Vine killers were applied on the average of 1.2 times.

Almost all of the vine killing was done with dinoseb, where a chemical was used. About 335,000 pounds (a.i.) were applied. Michigan and Wisconsin growers treated about 75 percent of their planted acres with dinoseb, Minnesota, 65 percent, and North Dakota about a 30 percent (Table 1, 6). Climatic conditions in North Dakota and Minnesota cause the vines to dry naturally or they are killed by frost. Growers use early maturing varieties, which is a factor in the reduced use of vine killers in North Dakota and Minnesota (4).

Table 5. Insecticide use on fall potatoes in the North Central region, 1979 a/

State and insecticide	Treated acres b/	Acre-treatment	Quantity applied (a.i.) Total	Per acre Treated	Per acre Treatment	Times applied
	1,000	1,000	1,000 lbs.	Lbs.	Lbs.	No.
Michigan						
Aldicarb	19.6	19.6	55.1	2.8	2.8	1.0
Azinphosmethyl	1.5	2.1	.9	.6	.4	1.4
Carbaryl	4.0	5.7	6.2	1.6	1.1	1.4
Carbofuran	2.4	3.1	6.7	2.8	2.2	1.3
Endosulfan	3.1	11.9	10.6	3.4	.9	3.8
Methamidophos	9.7	10.5	8.2	.8	.8	1.1
Monocrotophos	1.7	1.7	1.1	.6	.6	1.0
Parathion	7.3	22.9	9.9	1.4	.4	3.1
Other	-	3.6	5.8	-	1.6	-
Total	-	81.1	104.5	-	1.3	-
Minnesota						
Aldicarb	12.4	13.4	29.2	2.4	2.2	1.1
Azinphosmethyl	12.4	23.4	10.4	.8	.4	1.9
Carbaryl	10.2	20.2	15.4	1.5	.8	2.0
Dimethoate	5.7	11.3	2.8	.5	.2	2.0
Disulfoton	6.1	6.1	12.5	2.0	2.0	1.0
Endosulfan	6.9	10.7	6.1	.9	.6	1.6
Methamidophos	1.4	1.4	.7	.5	.5	1.0
Monocrotophos	2.4	6.3	5.6	2.3	.9	2.6
Phorate	6.9	7.8	17.8	2.6	2.3	1.1
Phosphamidon	7.6	16.1	10.0	1.3	.6	2.1
Other	-	1.5	3.1	-	2.1	-
Total	-	118.2	113.6	-	1.0	-
North Dakota						
Aldicarb	2.1	2.1	4.8	2.3	2.3	1.0
Azinphosmethyl	45.7	72.1	44.0	1.0	.6	1.6
Carbaryl	3.8	9.0	9.7	2.6	1.1	2.4
Dimethoate	5.1	18.3	9.3	1.8	.5	3.6
Disulfoton	12.5	12.5	23.2	1.9	1.9	1.0
Endosulfan	4.4	8.6	4.5	1.0	.5	2.0
Methamidophos	3.2	7.1	9.8	3.1	1.4	2.2
Monocrotophos	12.7	16.9	18.1	1.4	1.1	1.3
Phorate	35.9	35.9	74.0	2.1	2.1	1.0
Phosphamidon	8.5	15.0	9.0	1.1	.6	1.8
Other	-	4.1	2.2	-	.5	-
Total	-	201.6	208.6	-	1.0	-

-- continued

Table 5. Insecticide use on fall potatoes in the North Central region, 1979 a/ -- continued

State and insecticide	Treated acres b/	Acre-treatment	Quantity applied (a.i.) Total	Per acre Treated	Per acre Treatment	Times applied
	1,000	1,000	1,000 lbs.	Lbs.	Lbs.	No.
Wisconsin						
Aldicarb	19.8	19.8	52.6	2.7	2.7	1.0
Azinphosmethyl	2.1	5.0	2.5	1.2	.5	2.4
Carbaryl	20.4	49.9	53.7	2.6	1.1	2.4
Carbofuran	3.4	3.4	5.4	1.6	1.6	1.0
Disulfoton	9.4	9.4	22.7	2.4	2.4	1.0
Endosulfan	6.3	14.3	10.9	1.7	.8	2.3
Methamidophos	32.2	57.9	47.9	1.5	.8	1.8
Methomyl	7.1	10.9	9.8	1.4	.9	1.5
Parathion	8.4	17.6	8.9	1.1	.5	2.1
Phorate	8.8	8.8	22.8	2.6	2.6	1.0
Other	-	8.7	5.6	-	.6	-
Total	-	205.7	242.8	-	1.2	-
4 States c/						
Aldicarb	53.9	54.9	141.7	2.6	2.6	1.0
Azinphosmethyl	61.7	102.6	57.8	.9	.6	1.7
Carbaryl	38.5	84.8	85.0	2.2	1.0	2.2
Carbofuran	6.3	7.0	13.1	2.1	1.9	1.1
Dimethoate	12.1	31.6	12.8	1.1	.4	2.6
Disulfoton	28.6	28.6	60.7	2.1	2.1	1.0
Endosulfan	20.6	45.5	32.1	1.6	.7	2.2
Methamidophos	46.6	76.9	66.6	1.4	.9	1.7
Methomyl	7.4	11.2	9.9	1.3	.9	1.5
Monocrotophos	16.8	24.9	24.8	1.5	1.0	1.5
Parathion	16.2	41.0	19.0	1.2	.5	2.5
Phorate	51.9	52.8	115.3	2.2	2.2	1.0
Phosphamidon	17.0	31.9	19.4	1.1	.6	1.9
Other	-	12.9	11.3	-	.9	-
Total	-	606.6	669.5	-	1.1	-

a/ "1979 Fall Potato Pesticide Survey," USDA, ESCS, Natural Resource Economics Division.

b/ Data in this column for "other" and "total" were not reported because two or more materials may have been used on the same acre, resulting in multiple counting.

c/ Regional totals for specific materials may differ from the total for individual States because in some instances materials were included in the "other" category for State reporting.

Table 6. Vine killer use on fall potatoes in the North Central region, 1979 a/

State and vine killer	Treated acres b/	Acre-treatment	Quantity applied (a.i.) Total	Per acre Treated	Per acre Treatment	Times applied
	1,000	1,000	1,000 lbs.	Lbs.	Lbs.	No.
Michigan						
Dinoseb	25.8	30.0	70.5	2.7	2.4	1.2
Other	-	.3	.6	-	2.0	-
Total	-	30.3	71.1	-	2.3	-
Minnesota						
Dinoseb	45.8	61.3	105.1	2.3	1.7	1.3
Other	-	.5	.2	-	.4	-
Total	-	61.8	105.3	-	1.7	-
North Dakota						
Dinoseb	37.6	40.2	57.7	1.5	1.4	1.1
Other	-	1.8	1.2	-	.7	-
Total	-	42.0	58.9	-	1.4	-
Wisconsin						
Dinoseb	41.9	52.8	101.2	2.4	1.9	1.3
4 States						
Dinoseb	151.1	184.3	334.5	2.2	1.8	1.2
Other	-	2.6	2.0	-	.8	-
Total	-	186.9	336.5	-	1.8	-

a/ "1979 Fall Potato Pesticide Survey," USDA, ESCS, Natural Resource Economics Division.

b/ Data in this column for "other" and "total" were not reported because two or more materials may have been used on the same acre, resulting in multiple counting.

Growth regulators

Maleic hydrazide is the only chemical registered for field application to prevent potatoes sprouting in storage. It is sprayed on the plant 2 to 3 weeks after full bloom and is translocated to the tuber where it suppresses external and internal sprouting (9). Potatoes harvested in the fall are usually marketed from October to July. Those that are stored for extended periods of time without being treated with a growth regulator will sprout. Sprouting causes weight and quality loss. Potatoes that are to be stored from January to July are chemically treated with a growth regulator to reduce sprouting (9). Chlorpropham and tecnazene are other growth regulators used on potatoes, but they are applied in storage and for this reason were not reported in this survey.

Growers in North Dakota applied maleic hydrazide to about 14,000 acres 11 percent of the planted acreage (Table 1). Wisconsin growers treated a higher proportion of their acreage, 17 percent.

Another chemical registered as a growth regulator is 2,4-D. North Dakota has a special local need permit (24c) and growers reported using a small amount. Because of the limited number of observations the estimates of 2,4-D are included in the "other" category. 2,4-D is used to enhance the color of red potatoes.

Tank-mixes

Tank-mixes were 8 percent of all the acre-treatments made to control pests on potatoes and 13 percent of the pounds (a.i.) of pesticides used (Table 2).

Fentin hydroxide plus phosphamidon and carbaryl plus maneb/mancozeb were the most used tank-mixes, being applied in over 11,000 acre-treatments. They were reported used in North Dakota, Michigan, and Minnesota (Table 8). Azinphosmethyl plus maneb/mancozeb was used by growers in each of the four States in the North Central region. Maneb/mancozeb was reported in 8 of 19

Table 7. Growth regulator use on fall potatoes in the North Central region, 1979 a/

State and growth regulator	Treated acres b/	Acre-treatment	Quantity applied (a.i.) Total	Per acre Treated	Per acre Treatment	Times applied
	1,000	1,000	1,000 lbs.	Lbs.	Lbs.	No.
Michigan						
Maleic hydrazide	2.1	2.1	5.6	2.7	2.7	1.0
Minnesota						
Maleic hydrazide	3.3	3.3	11.2	3.5	3.4	1.0
North Dakota						
Maleic hydrazide	13.8	13.8	42.8	3.1	3.1	1.0
Other	-	.6	.1	-	.2	-
Total	-	14.4	42.9	-	3.0	-
Wisconsin						
Maleic hydrazide	9.6	9.6	28.3	2.9	2.9	1.0
4 States						
Maleic hydrazide	28.8	28.8	87.9	3.1	3.1	1.0
Other	-	.6	.1	-	.2	-
Total	-	29.4	88.0	-	3.0	-

a/ "1979 Fall Potato Pesticide Survey," USDA, ESCS, Natural Resource Economics Division.

b/ Data in this column for "other" and "total" were not reported because two or more materials may have been used on the same acre, resulting in multiple counting.

Table 8. Pesticides applied as tank-mixes to fall potatoes in the North Central region, 1979 a/

Tank-mixes	Treated acres b/	Acre-treatments	Total quantity lbs. a.i.	Times applied	States reporting c/
	1,000	1,000	1,000	No.	
Alachlor	7.2	7.3	11.6	1.0	MI, WI
+ linuron			5.1		
Alachlor	2.0	2.0	3.6	1.0	MI, WI
+ metribuzin			.9		
Azinphosmethyl	1.0	2.9	1.4	2.9	MN
+ captafol			2.5		
Azinphosmethyl	4.8	9.5	4.3	2.0	MI, MN, ND,
+ maneb/mancozeb d/			17.3		WI
Captafol	1.0	1.0	.8	1.0	MN
+ endosulfan			1.2		
Carbaryl	1.9	7.4	8.2	3.9	ND
+ dimethoate			3.7		
Carbaryl	3.9	11.1	10.7	2.8	MI, MN
+ maneb/mancozeb			14.1		
Chlorothalonil	1.9	3.3	2.3	1.7	MI, WI
+ methamidophos			2.4		
Chlorothalonil	1.2	3.3	2.9	2.8	MI
+ parathion			1.7		
Copper	2.1	4.5	3.7	2.1	MI
+ maneb/mancozeb			4.1		
Dimethoate	2.4	7.2	2.1	3.0	MN
+ fentin hydroxide			1.3		
Dimethoate	1.3	2.2	.7	1.7	MI, MN
+ maneb/mancozeb			3.0		
Endosulfan	1.1	2.7	1.1	2.5	MI, MN
+ maneb/mancozeb			4.0		
Endosulfan	1.8	2.3	1.7	1.3	MI
+ parathion			1.1		

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Table 8. Pesticides applied as tank-mixes to fall potatoes in the North Central region, 1979 a/ -- continued

Tank-mixes	Treated acres b/	Acre-treatments	Total quantity lbs. a.i.	Times applied	States reporting c/
	1,000			No.	
Fentin hydroxide + phosphamidon	3.8	11.4	1.4 5.0	3.0	ND
Maneb/mancozeb + methamidophos	3.6	7.3	10.4 6.5	2.0	MI, WI
Maneb/mancozeb + metiram	1.3	1.3	1.0 1.5	1.0	ND
Maneb/mancozeb + phosphamidon	1.9	3.9	4.8 1.9	2.1	MN
Methamidophos + metiram	2.1	4.3	2.4 6.6	2.0	MI
Other	-	86.5	211.3	-	-
Total	-	181.4	370.3	-	-

a/ "1979 Fall Potato Pesticide Survey," USDA, ESCS, Natural Resource Economics Division.
b/ Data in this column for "other" and "total" were not reported because two or more materials may have been used on the same acre, resulting in multiple counting.
c/ MI - Michigan, MN - Minnesota, ND - North Dakota, and WI - Wisconsin.
d/ Maneb and mancozeb are similar products; they are shown as one data entry.

tank-mixes with 42,500 acre-treatments, making it the most reported fungicide used in a mix. Carbaryl was second in importance used in a tank-mix at 18,500 acre-treatments.

Types of tank-mixes encountered in the survey were herbicide plus herbicide, insecticide plus insecticide, and fungicide plus insecticide. A fungicide plus insecticide was reported the most, with 70 percent of the mixes consisting of this combination. In all, 74 different tank-mixes were reported in the North Central region: 45 in Michigan, 14 in Minnesota, 10 in Wisconsin, and 5 in North Dakota.

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Appendix Table 1. Coefficients of variation for acres of potatoes treated with pesticides in the North Central region, 1979 a/

Pesticides	Michigan	Minnesota	North Dakota	Wisconsin	Region
Herbicides					
Alachlor	25	- b/	-	23	17
Chlorobromuron	- b/	-	-	57	50
Dalapon	- b/	-	-	31	30
EPTC	29	25	13	37	11
Linuron	14	34	-	17	11
Metribuzin	11	21	-	9	7
Fungicides					
Captafol	57	-	- b/	26	24
Chlorothalonil	18	37	57	15	11
Copper	12	-	-	27	11
Fentin hydroxide	- b/	25	11	21	9
Maneb/mancozeb c/	10	10	10	9	5
Metiram	32	40	-	29	19
Insecticides					
Aldicarb	10	18	53	12	7
Azinphosmethyl	44	17	9	44	8
Carbaryl	26	19	40	12	10
Carbofuran	34	- b/	-	34	24
Dimethoate	- b/	27	35	- b/	20
Disulfoton	- b/	26	21	19	13
Endosulfan	30	24	37	24	14
Methamidophos	15	57	44	8	7
Methomyl	- b/	-	-	23	22
Monocrotophos	40	44	21	-	17
Parathion	18	- b/	-	23	14
Phorate	- b/	24	10	20	8
Phosphamidon	-	23	26	- b/	17
Vine killer					
Dinoseb	5	5	10	5	3
Growth regulator					
Maleic hydrazide	37	37	20	19	13

- None reported.

a/ "1979 Fall Potato Pesticide Survey," USDA, ESCS, Natural Resource Economics Division.

b/ Use of this material at the State level was not significant.

c/ Maneb and mancozeb are similar products; they are shown as one data entry.

Appendix Table 2. Coefficients of variation for acres of potatoes treated with pesticides in the North Central region, 1979 a/

Pesticides	Michigan	Minnesota	North Dakota	Wisconsin	Region
	Percent				
Alachlor + linuron	57	-	-	24	23
Alachlor + metribuzin	70	-	-	52	42
Azinphosmethyl + captafol	-	70	-	-	70
Azinphosmethyl + maneb/mancozeb b/	72	70	44	- c/	33
Captafol + endosulfan	-	70	-	-	70
Carbaryl + dimethoate	-	-	57	-	57
Carbaryl + maneb/mancozeb	35	57	-	-	30
Chlorothalonil + methamidophos	44	-	-	- c/	41
Chlorothalonil + parathion	49	-	-	-	49
Copper + maneb/mancozeb	38	-	-	-	38
Dimethoate + fentin hydroxide	-	44	-	-	44
Dimethoate + maneb/mancozeb	- c/	70	-	-	59
Endosulfan + maneb/mancozeb	70	- c/	-	-	59
Endosulfan + parathion	40	-	-	-	40

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Appendix Table 2. Coefficients of variation for acres of potatoes treated with pesticides in the North Central region, 1979 a/ -- continued

Pesticides	Michigan	Minnesota	North Dakota	Wisconsin	Region
	Percent				
Fentin hydroxide + phosphamidon	-	-	40	-	40
Maneb/mancozeb + methamidophos	33	-	-	71	30
Maneb/mancozeb + metiram	-	-	71	-	71
Maneb/mancozeb + phosphamidon	-	49	-	-	49
Methamidophos + metiram	37	-	-	-	37

- None reported.
a/ "1979 Fall Potato Pesticide Survey," USDA, ESCS, Natural Resource Economics Division.
b/ Maneb and mancozeb are similar products; they are shown as one data entry.
c/ Use of this material at the State level was not significant.